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Attorney Docket No. JP919990123US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application

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Signature: Lisa L. Vulpis Date: January 14, 2004

Applicant(s): E. Colgan et al.
Docket No.: JP919990123US1
Serial No.: 09/662,192
Filing Date: September 14, 2000
Group: 2871
Examiner: Prasad R. Akkapeddi

Title: Liquid Crystal Light Valve and Method for Producing Same, and Liquid Crystal Projection Display Device

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APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants (hereinafter "Appellants") hereby appeal the final rejection dated June 12, 2003 of claims 1-6, 9-17, 20-28 and 31-36 of the above-identified application.

REAL PARTY IN INTEREST

The present application is assigned to International Business Machines Corporation (IBM Corp.), as evidenced by an assignment recorded September 14, 2000 in the U.S. Patent and Trademark Office at Reel 011140, Frame 0725. The assignee IBM Corp. is the real party in interest.

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RELATED APPEALS AND INTERFERENCES

There are no known related appeals and interferences.

STATUS OF CLAIMS

Claims 1-38 are pending in the present application. Claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-36 stand finally rejected under 35 U.S.C. §102(e). Claims 4, 9-11, 15, 20-22, 26 and

31-33 stand finally rejected under 35 U.S.C. §103(a). Claims 1-6, 9-17, 20-28 and 31-36 are appealed.

STATUS OF AMENDMENTS

There have been no amendments filed subsequent to the final rejection.

SUMMARY OF INVENTION

The present invention relates generally to techniques for forming a liquid crystal light valve, as may be used in a liquid crystal display device, that is capable of preventing an underlying transistor from malfunctioning due to a leakage of light incident from a light source (Specification; page 5, lines 16-19). Independent claims 1, 12 and 23 specify a liquid crystal light valve including a plurality of light-reflecting films with one or more spaces therebetween, a semiconductor substrate electrically connected to the light-reflecting films, and a counter substrate provided on an incident-light side of the substrate. Liquid crystal is disposed in a cell gap formed between the light-reflecting films and the counter substrate. An electric circuit is formed in the semiconductor substrate, which is configured to apply a voltage to the light-reflecting films and counter electrodes formed on the counter substrate. The liquid crystal light valve further includes a light-blocking layer formed below the light-reflecting films, a first insulating layer formed between the light-blocking layer and the electric circuit, and a second insulating layer formed between the light-reflecting films and the light-blocking layer. A stud is included which is configured to electrically connect the electric circuit and the light-reflecting films. Light shields are provided on the light-blocking layer formed below the light-reflecting films, and a third insulating layer is formed between the light shields and the light-reflecting films. At least one of the light shields and the light-blocking layer is configured to block the incident light from the electric circuit. Independent claims 34-36 specify a projection-type liquid crystal display device employing a liquid crystal light valve similar in scope to the liquid crystal light valve defined by claims 1, 12 and 23, respectively.

In the liquid crystal light valve of the present invention, the structure of the light shield for shielding the underlying transistor from the incident light from the space between the light-reflecting films is distinguishable from that of the conventional art. In accordance with one aspect of the

invention, stud-like light shields are each formed between the light-reflecting layers and the light-blocking films and along an inside peripheral portion of the light-reflecting layers (Specification; page 7, lines 15-17). Since the incident light from the space between the light-reflecting films can be effectively blocked, malfunction of an underlying transistor and pixel failure are eliminated, but yield and production efficiency are increased (Specification; page 7, lines 17-19).

In an illustrative embodiment of the invention, as shown in FIG. 1 of the drawings, a liquid crystal light valve 10 is shown. An electric circuit is formed on a silicon substrate 12 comprising a plurality of transistors 14, a storage capacitor 16, and an interconnecting layer (Specification; page 10, lines 21-23). On or more first insulating layers 18 are formed on the electric circuit, and light-blocking layers 20 are formed on the first insulating layers (Specification; page 10, lines 23-25). On the light-blocking layers 20, one or more second insulating layers 22 are formed, and on the second insulating layers 22, a plurality of light-reflecting films 24, each separated by a space 26, are provided for each transistor 14 (Specification; page 10, line 25 to page 11, line 3).

In the liquid crystal light valve 10, light shields 38 are formed below the peripheral portions of the light-reflecting films 24 (Specification; page 11, lines 8-9). The alignment of liquid crystal molecules varies in response to a voltage applied to counter electrodes 36 and the light-reflecting films, and a transmittance of light is thereby changed (Specification; page 11, lines 9-12). The light-reflecting films 24 are separated by space 26. One light-reflecting film 24 constitutes one pixel. Each of the light-reflecting films 24 is electrically connected to each of the transistors 14 by stud 46 in a groove bored in first insulating layer 18 and second insulating layer 22 (Specification; page 12, lines 10-12).

In terms of allowable amount of leakage of light to a lower layer in the liquid crystal light valve and alignment accuracy in a photolithographic step, the light shields 38 are preferably formed below the inside peripheral portions of the light-reflecting films 24. One or more third insulating layers 50 are thin layers covering the light shields 38 and the second insulating layers 22 (Specification; page 15, lines 19-20). Being brought into close contact with the second insulating layers 22, the third insulating layers 50 serve to cover up pinholes and the like on the surfaces of the second insulating layers (Specification; page 15, lines 20-22). Even if the light shields 38 are conductive, the third insulating layers 50 electrically isolate the light-reflecting films 24 from the

light-blocking layers 20 and may hold a constant electric capacitance (Specification; page 16, lines 1-3). Consequently, a part of the storage capacitance necessary to drive each liquid crystal pixel can be provided by the third insulating layers 50, in accordance with another aspect of the invention (Specification; page 16, lines 9-12).

ISSUES PRESENTED FOR REVIEW

1. Whether claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-36 are properly rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 6,081,305 to Sato et al. (hereinafter "Sato").

2. Whether claims 4, 9-11, 15, 20-22, 26 and 31-33 are properly rejected under 35 U.S.C. §103(a) as being unpatentable over Sato, in view of U.S. Patent No. 5,056,895 to Kahn (hereinafter "Kahn").

GROUPING OF CLAIMS

Issues 1 and 2 above each involve a ground of rejection which Appellants contest and which applies to a group of two or more claims. With regard to these claims, claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-36 do not stand or fall together (claims 1, 3, 5, 12, 14, 16, 23, 25 and 27 stand or fall together, claims 2, 13 and 24 stand or fall together and are believed to be separately patentable, and claims 6, 17 and 28 stand or fall together and are believed to be separately patentable), and claims 4, 9-11, 15, 20-22, 26 and 31-33 stand or fall together.

ARGUMENT

Issue 1

A. Claims 1, 3, 5, 12, 14, 16, 23, 25 and 27

As was noted above, independent claims 1, 12 and 23 specify a liquid crystal light valve including a plurality of light-reflecting films with one or more spaces therebetween, a semiconductor substrate electrically connected to the light-reflecting films, and a counter substrate provided on an incident-light side of the substrate. Liquid crystal is disposed in a cell gap formed between the light-reflecting films and the counter substrate. An electric circuit is formed in the semiconductor

substrate, which is configured to apply a voltage to the light-reflecting films and counter electrodes formed on the counter substrate. The liquid crystal light valve further includes a light-blocking layer formed below the light-reflecting films, a first insulating layer formed between the light-blocking layer and the electric circuit, and a second insulating layer formed between the light-reflecting films and the light-blocking layer. A stud is included which is configured to electrically connect the electric circuit and the light-reflecting films. Light shields are provided on the light-blocking layer formed below the light-reflecting films, and a third insulating layer is formed between the light shields and the light-reflecting films. At least one of the light shields and the light-blocking layer is configured to block the incident light from the electric circuit. Independent claims 34-36 specify a projection-type liquid crystal display device employing a liquid crystal light valve similar in scope to the liquid crystal light valve defined by claims 1, 12 and 23, respectively.

Claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-37 stand rejected under §102(e) as being anticipated by the Sato reference. Specifically, with regard to independent claims 1, 12, 23 and 34-36, the Examiner contends that Sato, with reference to FIG. 2, discloses a liquid crystal light valve comprising "a light-blocking layer (163) formed below the light-reflecting films (140, 160 and 180)" and "light shields (164) provided on the light-blocking layer formed below the light-reflecting films (180)" (final Office Action; page 3, last paragraph to page 4, first paragraph). Appellants respectfully disagree with the Examiner's contentions.

With regard to independent claims 1, 12, 23 and 34-36, Appellants submit that Sato fails to teach or suggest at least "light shields provided on the light-blocking layer," as required by the subject claims. The Examiner analogizes the light-blocking layer and light shields to the shading layer 163 and middle electrode 164, respectively, shown in FIG. 2 of Sato. However, Appellants disagree with this characterization of the prior art and submit that the shading layer 163 and middle electrode 164 in Sato are functionally non-analogous to the light-blocking layer (20) and light shields (38), respectively, of the claimed invention. For example, Sato discloses that the shading layer 163 is formed as patterns on the second metal layer 160 that "reflect or absorb incident light, thereby shading light reaching the semiconductor elements" (Sato; column 13, lines 53-54, 59-62; emphasis added). In contrast, the light-blocking layer of the claimed invention is clearly defined such that it

"prevents a reflection of light transmitted to the light-blocking layer 20" (Specification; page 12, lines 21-22; emphasis added). Thus, Sato in fact teaches away from the claimed invention.

In the Examiner's Advisory Action dated October 14, 2003, the Examiner contends that Sato's metal layer 160 reflects or absorbs incident light, and "[h]ence, absorption does prevent light from being reflected" (Advisory Action; page 2, Continuation of Item 5). Appellants respectfully disagree with this contention. First, Sato clearly describes pixel electrodes 181 as "reflectors" (Sato; column 14, line 62; emphasis added). Although Sato also refers to layers 163 and 181 as "shading layers" (Sato; column 13; lines 58-59), each of the two layers actually function by reflecting incident light. Sato describes the two layers 163 and 181 as each including slits 162 and 182, respectively, that are non-overlapping with respect to one another. The shading layer 163, by itself, is not capable of blocking light. Since each layer 163 and 181 reflects incident light, the two separate layers 163 and 181 must be used in conjunction with one another to provide "shading of the irradiation light" (Sato; column 15, line 20). Specifically, Sato states:

> A light entering from the slit 182 between the reflecting pixels 181 formed in the third metal layer 180, which is the uppermost section, is shaded by the shading layer 163 formed in the second metal layer 160. That is, when it is seen from the facing substrate 300 side, since the slit 182 formed in the third metal layer 180 and the slit 162 formed in the second metal layer 160 are not overlapped, but are disposed so as to be offset from each other, the light entering from the facing substrate 300 side is reflected by either one of the third and second metal layers, so that it doesn't reach the semiconductor substrate 110. (Sato; column 15, lines 20-31; emphasis added)

Consequently, Appellants submit that Sato fails to teach or suggest a "light-blocking layer" as explicitly set forth in claims 1, 12, 23 and 34-36.

Even assuming, *arguendo*, that the "shading layer" taught by Sato can be analogized to the light-blocking layer recited in the subject claims, Appellants assert that Sato still fails to disclose, among other elements, light shields formed on the light-blocking layer, as required by the claimed invention. Rather, Sato clearly discloses that the middle electrode 164 and shading layer 163 are both formed within the same layer, namely, second metal layer 160 (Sato; column 14, lines 58-59; FIG. 2), and thus one structure cannot be formed on top of the other.

Sato further fails to disclose at least two insulating layers formed between the light-reflecting films and the light-blocking layer, as set forth in the subject claims (Specification; FIG. 1). In this regard, the Examiner contends that 'the formation of at least two insulating layers between any pair of such light-reflecting films and light-blocking layer', is not recited in the instant claims 1, 12 or 23" (final Office Action; page 7, last paragraph). Applicants respectfully disagree with this contention.

Specifically, claim 1, for example, recites "a second insulating layer formed between the light-reflecting films and the light-blocking layer" and "a third insulating layer formed between the light shields and the light-reflecting films." Clearly, the second insulating layer is required to be formed between the light-reflecting films and the light-blocking layer. Additionally, since claim 1 requires that the light shields are "provided on the light-blocking layer formed below the light-reflecting films" (emphasis added), it deductively follows that the third insulating layer is also formed between the light-reflecting films and the light-blocking layer. Thus, the claimed invention does require at least two insulating layers, namely, second insulating layer (22) and third insulating layer (50), formed between the light-reflecting films (24) and the light-blocking layer (20). This is also clearly evident from FIG. 1. As previously stated, Sato clearly fails to disclose a liquid crystal light valve having this arrangement.

With regard to Sato, the Examiner analogizes the light-reflecting films recited in the subject claims to the first, second and third metal layers 140, 160 and 180, respectively, in Sato. Assuming, *arguendo*, that this analogy is even reasonably valid, the claimed invention specifically requires that the light shields (38) be formed below the light-reflecting films 24 (plural), implying that the light shields are formed below all of the light-reflecting films, since a single light-reflecting film is not specified by the claim. The Examiner analogizes the middle electrode 164 in Sato to the light shields of the present invention. However, in the structure disclosed by Sato, the middle electrode 164 is formed below only one of the metal layers, namely, the third metal layer 180. Thus, the disclosure of Sato cannot reasonably support the specific arrangement of the liquid crystal light valve recited in the subject claims.

Inasmuch as the Sato reference fails to teach or suggest the present invention as claimed, Appellants submit that independent claims 1, 12, 23 and 34-36 are patentable over the prior art.

Claims 3 and 5 depend from claim 1 and are therefore believed to be patentable for at least the reasons set forth above with respect to claim 1.

Claims 14 and 16 depend from claim 12 and are therefore believed to be patentable for at least the reasons set forth above with respect to claim 12.

Claims 25 and 27 depend from claim 23 and are therefore believed to be patentable for at least the reasons set forth above with respect to claim 23.

B. Claims 2, 13 and 24

Claims 2, 13 and 24 further specify that the light-blocking layer in the liquid crystal light valve as being "formed just below the light shields." Appellants respectfully submit that the cited prior art fails to teach or suggest this arrangement. Instead, Sato clearly discloses that the middle electrode, which the Examiner analogizes to the light shields, and the shading layer, which the Examiner analogizes to the light-blocking layer, are formed in the same layer, namely, second metal layer 160 (Sato; column 14, lines 58-59). Consequently, if two layers are formed in the same layer, one of the layers cannot be formed below the other, as required by the subject claims.

For at least the above reasons, Appellants assert that claims 2, 13 and 24 are separately patentable.

C. Claims 6, 17 and 28

Claims 6, 17 and 28 further specify that the light-blocking layers in the liquid crystal light valve as being "formed by laminating at least one metal selected from the group consisting of Al, Cr-Cr_xO_y, Ti, TiN, and TiN_xC_y." Appellants respectfully submit that Sato fails to teach or remotely suggest that the shading layer 163, which the Examiner analogizes to the light-blocking layer of the claimed invention, is formed as a laminated structure. The Examiner fails to point out with any specificity where in Sato the claimed arrangement is disclosed, and, furthermore, fails to address such additional feature of the claimed invention at all.

For at least the above reasons, Appellants assert that claims 6, 17 and 28 are separately patentable.

Issue 2

Appellants hereby re-allege and incorporate by reference the arguments relating to Issue 1 above in their entirety.

Claims 4, 9-11, 15, 20-22, 26 and 31-33 stand rejected under §103(a) as being unpatentable over Sato, in view of Kahn. Specifically, with regard to claims 4, 15 and 26, the Examiner acknowledges that Sato fails to disclose the materials used to form the insulating layers and/or that the electric circuit formed in the substrate does not include a storage capacitance, as set forth in one or more of the subject claims final Office Action; page 5, last paragraph). However, the Examiner contends that such limitations are disclosed in Kahn. Appellants respectfully disagree with this contention.

Claims 4, 15, and 26 further specify that the electric circuit in the liquid crystal light valve recited in claims 1, 12 and 25, respectively, does not have a storage capacitor. The Examiner contends that Kahn discloses this feature of claims 4, 14 and 26 at column 6, line 67 to column 7, line 2, where it states that "[i]n the second embodiment, the liquid crystal material composition has a large enough intrinsic RC time constant (rho * epsilon greater than one frame) that additional storage capacitors are not needed" (emphasis added). Appellants submit, however, that the Examiner's characterization of the Kahn reference is incorrect.

With reference to FIG. 2 of Kahn, which illustrates a second embodiment of Kahn's invention (Kahn; column 4, lines 32-34), Kahn states that "the second embodiment lacks capacitive layer 66 and insulation layer 68 found in the first embodiment. The lack of these layers provides a less complicated, less costly cell" (Kahn; column 7, lines 9-12). However, while the second embodiment of Kahn may disclose that additional capacitors are not needed (Kahn; column 7, line 2), this embodiment still requires the inclusion of a storage capacitor. Specifically, FIG. 2 of Kahn depicts a storage capacitor comprising a top electrode 70, capacitor structure 64, oxide layers 53 and 50, and bottom electrode 44 (drain bus). This is explicitly described in Kahn at column 5, lines 35-53. Appellants assert that structure 64, which is clearly defined in Kahn as a "capacitor structure" (Kahn; column 5, lines 36-40), is shown in all embodiments described in Kahn (*see, e.g.*, Kahn; FIGS. 1A, 2 and 3). Accordingly, Kahn fails to supplement the deficiencies of Sato.

In view of the foregoing, Appellants respectfully assert that claims 4, 15 and 26 are patentable over the prior art of record, not merely by virtue of their dependency from claims 1, 12 and 25, respectively, which are believed to be patentable for at least the reasons set forth in Issue 1 above, but also in their own right.

Claims 9-11 depend from claim 1 and are therefore believed to be patentable for at least the reasons set forth in Issue 1 above with respect to claim 1.

Claims 20-22 depend from claim 12 and are therefore believed to be patentable for at least the reasons set forth in Issue 1 above with respect to claim 12.

Claims 31-33 depend from claim 23 and are therefore believed to be patentable for at least the reasons set forth in Issue 1 above with respect to claim 23.

Respectfully submitted,

Date: January 14, 2004

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APPENDIX

1. A liquid crystal light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter-substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

2. The liquid crystal light valve according to claim 1, wherein the light-blocking layer is formed just below the light shields.

3. The liquid crystal light valve according to claim 1, wherein the electric circuit in the semiconductor substrate has a storage capacitance.

4. The liquid crystal light valve according to claim 1, wherein the electric circuit in the semiconductor substrate does not have a storage capacitance.

5. The liquid crystal light valve according to claim 1, wherein the stud and the light shields are formed from one substance selected from the group consisting of Ti, W, Mo, Cu, Al, alloys thereof, and compounds thereof with silicon.

6. The liquid crystal light valve according to claim 1, wherein the light-blocking layers are formed by laminating at least one metal selected from a group consisting of Al, Cr-Cr_xO_y, Ti, TiN, and TiN_xC_y.

7. The liquid crystal light valve according to claim l, wherein the third insulating layer has a thickness of 50 Å to 1000 Å.

8. The liquid crystal light valve according to claim 1, wherein the light-reflecting films have ends, and wherein the light shields are formed below the inside peripheral portions of the light-reflecting films at least 0.2 μm from the ends thereof.

9. The liquid crystal light valve according to claim 1, wherein the first, the second, and the third insulating layers contain at least one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, ZrO_x, diamond carbon, and polyamide.

10. The liquid crystal light valve according to claim 9, wherein the first and the second insulating layers are formed from one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, and ZrO_x.

11. The liquid crystal light valve according to claim 9, wherein the third insulating layer is formed from one substance selected from the group consisting of Si_3N_4, TaO_x, and ZrO_x.

12. A liquid crystal light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the inside peripheral portions of the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer are configured to block the incident light from the electric circuit.

13. The liquid crystal light valve according to claim 12, wherein the light-blocking layer is formed just below the light shields.

14. The liquid crystal light valve according to claim 12, wherein the electric circuit in the semiconductor substrate has a storage capacitance.

15. The liquid crystal light valve according to claim 12, wherein the electric circuit in the semiconductor substrate does not have a storage capacitance.

16. The liquid crystal light valve according to claim 12, wherein the stud and the light shields are formed from one substance selected from the group consisting of Ti, W, Mo, Cu, Al, alloys thereof, and compounds thereof with silicon.

17. The liquid crystal light valve according to claim 12, wherein the light-blocking layers are formed by laminating at least one metal selected from a group consisting of Al, Cr-Cr_x0_y, Ti, TiN, and TiN_xC_y.

18. The liquid crystal light valve according to claim 12, wherein the third insulating layer has a thickness of 50 Å to 1000 Å.

19. The liquid crystal light valve according to claim 12, wherein the light-reflecting films have ends, and wherein the light shields are formed below the inside peripheral portions of the light-reflecting films at least 0.2 μm from the ends thereof.

20. The liquid crystal light valve according to claim 12, wherein the first, the second, and the third insulating layers contain at least one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, ZrO_x, diamond carbon, and polyamide.

21. The liquid crystal light valve according to claim 20, wherein the first and the second insulating layers are formed from one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, and ZrO_x.

22. The liquid crystal light valve according to claim 20, wherein the third insulating layer is formed from one substance selected from the group consisting of Si_3N_4, TaO_x, and ZrO_x.

23. A liquid crystal light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap between the light-reflecting films and the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields formed below the area including the inside peripheral portions of the light-reflecting films and the space between the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

24. The liquid crystal light valve according to claim 23, wherein the light-blocking layer is formed just below the light shields.

25. The liquid crystal light valve according to claim 23, wherein the electric circuit in the semiconductor substrate has a storage capacitance.

26. The liquid crystal light valve according to claim 23, wherein the electric circuit in the semiconductor substrate does not have a storage capacitance.

27. The liquid crystal light valve according to claim 23, wherein the stud and the light shields are formed from one substance selected from the group consisting of Ti, W, Mo, Cu, Al, alloys thereof, and compounds thereof with silicon.

28. The liquid crystal light valve according to claim 23, wherein the light-blocking layers are formed by laminating at least one metal selected from a group consisting of Al, Cr-Cr_xO_y, Ti, TiN, and TiN_xC_y.

29. The liquid crystal light valve according to claim 23, wherein the third insulating layer has a thickness of 50 Å to 1000 Å.

30. The liquid crystal light valve according to claim 23, wherein the light-reflecting films have ends, and wherein the light shields are formed below the inside peripheral portions of the light-reflecting films at least 0.2 μm from the ends thereof.

31. The liquid crystal light valve according to claim 23, wherein the first, the second, and the third insulating layers contain at least one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, ZrO_x, diamond carbon, and polyamide.

32. The liquid crystal light valve according to claim 31, wherein the first and the second insulating layers are formed from one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, and ZrO_x.

33. The liquid crystal light valve according to claim 31, wherein the third insulating layer is formed from one substance selected from the group consisting of Si_3N_4, TaO_x, and ZrO_x.

34. A projection-type liquid crystal display device comprising:

a light source;

a projection lens; and

a light valve, said light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter-substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

35. A projection-type liquid crystal display device comprising:

a light source;

a projection lens; and

a light valve, said light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the inside peripheral portions of the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer are configured to block the incident light from the electric circuit.

36. A projection-type liquid crystal display device comprising:

a light source;

a projection lens; and

a light valve, said light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap between the light-reflecting films and the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields formed below the area including the inside peripheral portions of the light-reflecting films and the space between the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

37. A method for producing a liquid crystal light valve comprising:

(a) forming a semiconductor substrate, wherein said step of forming a semiconductor substrate comprises the sub-steps of:

(i) forming an electric circuit in the semiconductor substrate for a plurality of light-reflecting films;

(ii) forming a first insulating layer on the electric circuit;

(iii) forming a light-blocking layer on the first insulating layer;

(iv) boring a hole for a stud in the light-blocking layer;

(v) forming a second insulating layer on the light-blocking layer, wherein said second insulating layer has an upper surface;

(vi) boring a groove for a stud in the second insulating layer and the first insulating layer;

(vii) boring grooves for light shields in the second insulating layer;

(viii) forming a stud in the hole in the light-blocking layer and in the grooves in the first and the second insulating layers, said stud configured to electrically connect the light-reflecting films and the electric circuit, wherein said stud has an upper surface;

(ix) forming light shields on the light-blocking layer, which shields are configured to block incident light from a space between the light-reflecting films, wherein said light shields have an upper surface;

(x) forming a third insulating layer all over the upper surfaces of the second insulating layer, the stud, and the light shields;

(xi) removing the third insulating layer from the upper surface of the stud; and

(xii) forming the plurality of light-reflecting films patterned for each electric circuit on the third insulating layer; and

(b) forming a liquid crystal panel, wherein said step of forming a liquid crystal panel comprises the sub-steps of:

(i) aligning the semiconductor substrate and a counter substrate having a counter electrode; and

(ii) filling liquid crystal in a cell gap formed by a spacer, said cell gap formed between the light reflecting films and the counter electrodes.

38. The method of claim 37, wherein said sub-steps (a)(vi) and (a)(vii) are performed substantially together, and wherein said sub-steps (a)(viii) and (a)(ix) are performed substantially together.

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Attorney Docket No. JP919990123US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application

I hereby certify that this paper is being deposited on this date with the U.S. Postal Service as first class mail addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Signature: Lisa L. Vulpis Date: January 14, 2004

Applicant(s): E. Colgan et al.
Docket No.: JP919990123US1
Serial No.: 09/662,192
Filing Date: September 14, 2000
Group: 2871
Examiner: Prasad R. Akkapeddi

Title: Liquid Crystal Light Valve and Method for Producing Same, and Liquid Crystal Projection Display Device

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APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants (hereinafter "Appellants") hereby appeal the final rejection dated June 12, 2003 of claims 1-6, 9-17, 20-28 and 31-36 of the above-identified application.

REAL PARTY IN INTEREST

The present application is assigned to International Business Machines Corporation (IBM Corp.), as evidenced by an assignment recorded September 14, 2000 in the U.S. Patent and Trademark Office at Reel 011140, Frame 0725. The assignee IBM Corp. is the real party in interest.

RELATED APPEALS AND INTERFERENCES

There are no known related appeals and interferences.

STATUS OF CLAIMS

Claims 1-38 are pending in the present application. Claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-36 stand finally rejected under 35 U.S.C. §102(e). Claims 4, 9-11, 15, 20-22, 26 and

31-33 stand finally rejected under 35 U.S.C. §103(a). Claims 1-6, 9-17, 20-28 and 31-36 are appealed.

STATUS OF AMENDMENTS

There have been no amendments filed subsequent to the final rejection.

SUMMARY OF INVENTION

The present invention relates generally to techniques for forming a liquid crystal light valve, as may be used in a liquid crystal display device, that is capable of preventing an underlying transistor from malfunctioning due to a leakage of light incident from a light source (Specification; page 5, lines 16-19). Independent claims 1, 12 and 23 specify a liquid crystal light valve including a plurality of light-reflecting films with one or more spaces therebetween, a semiconductor substrate electrically connected to the light-reflecting films, and a counter substrate provided on an incident-light side of the substrate. Liquid crystal is disposed in a cell gap formed between the light-reflecting films and the counter substrate. An electric circuit is formed in the semiconductor substrate, which is configured to apply a voltage to the light-reflecting films and counter electrodes formed on the counter substrate. The liquid crystal light valve further includes a light-blocking layer formed below the light-reflecting films, a first insulating layer formed between the light-blocking layer and the electric circuit, and a second insulating layer formed between the light-reflecting films and the light-blocking layer. A stud is included which is configured to electrically connect the electric circuit and the light-reflecting films. Light shields are provided on the light-blocking layer formed below the light-reflecting films, and a third insulating layer is formed between the light shields and the light-reflecting films. At least one of the light shields and the light-blocking layer is configured to block the incident light from the electric circuit. Independent claims 34-36 specify a projection-type liquid crystal display device employing a liquid crystal light valve similar in scope to the liquid crystal light valve defined by claims 1, 12 and 23, respectively.

In the liquid crystal light valve of the present invention, the structure of the light shield for shielding the underlying transistor from the incident light from the space between the light-reflecting films is distinguishable from that of the conventional art. In accordance with one aspect of the

invention, stud-like light shields are each formed between the light-reflecting layers and the light-blocking films and along an inside peripheral portion of the light-reflecting layers (Specification; page 7, lines 15-17). Since the incident light from the space between the light-reflecting films can be effectively blocked, malfunction of an underlying transistor and pixel failure are eliminated, but yield and production efficiency are increased (Specification; page 7, lines 17-19).

In an illustrative embodiment of the invention, as shown in FIG. 1 of the drawings, a liquid crystal light valve 10 is shown. An electric circuit is formed on a silicon substrate 12 comprising a plurality of transistors 14, a storage capacitor 16, and an interconnecting layer (Specification; page 10, lines 21-23). On or more first insulating layers 18 are formed on the electric circuit, and light-blocking layers 20 are formed on the first insulating layers (Specification; page 10, lines 23-25). On the light-blocking layers 20, one or more second insulating layers 22 are formed, and on the second insulating layers 22, a plurality of light-reflecting films 24, each separated by a space 26, are provided for each transistor 14 (Specification; page 10, line 25 to page 11, line 3).

In the liquid crystal light valve 10, light shields 38 are formed below the peripheral portions of the light-reflecting films 24 (Specification; page 11, lines 8-9). The alignment of liquid crystal molecules varies in response to a voltage applied to counter electrodes 36 and the light-reflecting films, and a transmittance of light is thereby changed (Specification; page 11, lines 9-12). The light-reflecting films 24 are separated by space 26. One light-reflecting film 24 constitutes one pixel. Each of the light-reflecting films 24 is electrically connected to each of the transistors 14 by stud 46 in a groove bored in first insulating layer 18 and second insulating layer 22 (Specification; page 12, lines 10-12).

In terms of allowable amount of leakage of light to a lower layer in the liquid crystal light valve and alignment accuracy in a photolithographic step, the light shields 38 are preferably formed below the inside peripheral portions of the light-reflecting films 24. One or more third insulating layers 50 are thin layers covering the light shields 38 and the second insulating layers 22 (Specification; page 15, lines 19-20). Being brought into close contact with the second insulating layers 22, the third insulating layers 50 serve to cover up pinholes and the like on the surfaces of the second insulating layers (Specification; page 15, lines 20-22). Even if the light shields 38 are conductive, the third insulating layers 50 electrically isolate the light-reflecting films 24 from the

light-blocking layers 20 and may hold a constant electric capacitance (Specification; page 16, lines 1-3). Consequently, a part of the storage capacitance necessary to drive each liquid crystal pixel can be provided by the third insulating layers 50, in accordance with another aspect of the invention (Specification; page 16, lines 9-12).

ISSUES PRESENTED FOR REVIEW

1. Whether claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-36 are properly rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 6,081,305 to Sato et al. (hereinafter "Sato").

2. Whether claims 4, 9-11, 15, 20-22, 26 and 31-33 are properly rejected under 35 U.S.C. §103(a) as being unpatentable over Sato, in view of U.S. Patent No. 5,056,895 to Kahn (hereinafter "Kahn").

GROUPING OF CLAIMS

Issues 1 and 2 above each involve a ground of rejection which Appellants contest and which applies to a group of two or more claims. With regard to these claims, claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-36 do not stand or fall together (claims 1, 3, 5, 12, 14, 16, 23, 25 and 27 stand or fall together, claims 2, 13 and 24 stand or fall together and are believed to be separately patentable, and claims 6, 17 and 28 stand or fall together and are believed to be separately patentable), and claims 4, 9-11, 15, 20-22, 26 and 31-33 stand or fall together.

ARGUMENT

Issue 1

A. Claims 1, 3, 5, 12, 14, 16, 23, 25 and 27

As was noted above, independent claims 1, 12 and 23 specify a liquid crystal light valve including a plurality of light-reflecting films with one or more spaces therebetween, a semiconductor substrate electrically connected to the light-reflecting films, and a counter substrate provided on an incident-light side of the substrate. Liquid crystal is disposed in a cell gap formed between the light-reflecting films and the counter substrate. An electric circuit is formed in the semiconductor

substrate, which is configured to apply a voltage to the light-reflecting films and counter electrodes formed on the counter substrate. The liquid crystal light valve further includes a light-blocking layer formed below the light-reflecting films, a first insulating layer formed between the light-blocking layer and the electric circuit, and a second insulating layer formed between the light-reflecting films and the light-blocking layer. A stud is included which is configured to electrically connect the electric circuit and the light-reflecting films. Light shields are provided on the light-blocking layer formed below the light-reflecting films, and a third insulating layer is formed between the light shields and the light-reflecting films. At least one of the light shields and the light-blocking layer is configured to block the incident light from the electric circuit. Independent claims 34-36 specify a projection-type liquid crystal display device employing a liquid crystal light valve similar in scope to the liquid crystal light valve defined by claims 1, 12 and 23, respectively.

Claims 1-3, 5, 6, 12-14, 16, 17, 23-25, 27, 28 and 34-37 stand rejected under §102(e) as being anticipated by the Sato reference. Specifically, with regard to independent claims 1, 12, 23 and 34-36, the Examiner contends that Sato, with reference to FIG. 2, discloses a liquid crystal light valve comprising "a light-blocking layer (163) formed below the light-reflecting films (140, 160 and 180)" and "light shields (164) provided on the light-blocking layer formed below the light-reflecting films (180)" (final Office Action; page 3, last paragraph to page 4, first paragraph). Appellants respectfully disagree with the Examiner's contentions.

With regard to independent claims 1, 12, 23 and 34-36, Appellants submit that Sato fails to teach or suggest at least "light shields provided on the light-blocking layer," as required by the subject claims. The Examiner analogizes the light-blocking layer and light shields to the shading layer 163 and middle electrode 164, respectively, shown in FIG. 2 of Sato. However, Appellants disagree with this characterization of the prior art and submit that the shading layer 163 and middle electrode 164 in Sato are functionally non-analogous to the light-blocking layer (20) and light shields (38), respectively, of the claimed invention. For example, Sato discloses that the shading layer 163 is formed as patterns on the second metal layer 160 that "reflect or absorb incident light, thereby shading light reaching the semiconductor elements" (Sato; column 13, lines 53-54, 59-62; emphasis added). In contrast, the light-blocking layer of the claimed invention is clearly defined such that it

"prevents a reflection of light transmitted to the light-blocking layer 20" (Specification; page 12, lines 21-22; emphasis added). Thus, Sato in fact teaches away from the claimed invention.

In the Examiner's Advisory Action dated October 14, 2003, the Examiner contends that Sato's metal layer 160 reflects or absorbs incident light, and "[h]ence, absorption does prevent light from being reflected" (Advisory Action; page 2, Continuation of Item 5). Appellants respectfully disagree with this contention. First, Sato clearly describes pixel electrodes 181 as "reflectors" (Sato; column 14, line 62; emphasis added). Although Sato also refers to layers 163 and 181 as "shading layers" (Sato; column 13; lines 58-59), each of the two layers actually function by reflecting incident light. Sato describes the two layers 163 and 181 as each including slits 162 and 182, respectively, that are non-overlapping with respect to one another. The shading layer 163, by itself, is not capable of blocking light. Since each layer 163 and 181 reflects incident light, the two separate layers 163 and 181 must be used in conjunction with one another to provide "shading of the irradiation light" (Sato; column 15, line 20). Specifically, Sato states:

> A light entering from the slit 182 between the reflecting pixels 181 formed in the third metal layer 180, which is the uppermost section, is shaded by the shading layer 163 formed in the second metal layer 160. That is, when it is seen from the facing substrate 300 side, since the slit 182 formed in the third metal layer 180 and the slit 162 formed in the second metal layer 160 are not overlapped, but are disposed so as to be offset from each other, the light entering from the facing substrate 300 side is reflected by either one of the third and second metal layers, so that it doesn't reach the semiconductor substrate 110. (Sato; column 15, lines 20-31; emphasis added)

Consequently, Appellants submit that Sato fails to teach or suggest a "light-blocking layer" as explicitly set forth in claims 1, 12, 23 and 34-36.

Even assuming, *arguendo*, that the "shading layer" taught by Sato can be analogized to the light-blocking layer recited in the subject claims, Appellants assert that Sato still fails to disclose, among other elements, light shields formed on the light-blocking layer, as required by the claimed invention. Rather, Sato clearly discloses that the middle electrode 164 and shading layer 163 are both formed within the same layer, namely, second metal layer 160 (Sato; column 14, lines 58-59; FIG. 2), and thus one structure cannot be formed on top of the other.

Sato further fails to disclose at least two insulating layers formed between the light-reflecting films and the light-blocking layer, as set forth in the subject claims (Specification; FIG. 1). In this regard, the Examiner contends that 'the formation of at least two insulating layers between any pair of such light-reflecting films and light-blocking layer', is not recited in the instant claims 1, 12 or 23" (final Office Action; page 7, last paragraph). Applicants respectfully disagree with this contention.

Specifically, claim 1, for example, recites "a second insulating layer formed between the light-reflecting films and the light-blocking layer" and "a third insulating layer formed between the light shields and the light-reflecting films." Clearly, the second insulating layer is required to be formed between the light-reflecting films and the light-blocking layer. Additionally, since claim 1 requires that the light shields are "provided on the light-blocking layer formed below the light-reflecting films" (emphasis added), it deductively follows that the third insulating layer is also formed between the light-reflecting films and the light-blocking layer. Thus, the claimed invention does require at least two insulating layers, namely, second insulating layer (22) and third insulating layer (50), formed between the light-reflecting films (24) and the light-blocking layer (20). This is also clearly evident from FIG. 1. As previously stated, Sato clearly fails to disclose a liquid crystal light valve having this arrangement.

With regard to Sato, the Examiner analogizes the light-reflecting films recited in the subject claims to the first, second and third metal layers 140, 160 and 180, respectively, in Sato. Assuming, *arguendo*, that this analogy is even reasonably valid, the claimed invention specifically requires that the light shields (38) be formed below the light-reflecting films 24 (plural), implying that the light shields are formed below all of the light-reflecting films, since a single light-reflecting film is not specified by the claim. The Examiner analogizes the middle electrode 164 in Sato to the light shields of the present invention. However, in the structure disclosed by Sato, the middle electrode 164 is formed below only one of the metal layers, namely, the third metal layer 180. Thus, the disclosure of Sato cannot reasonably support the specific arrangement of the liquid crystal light valve recited in the subject claims.

Inasmuch as the Sato reference fails to teach or suggest the present invention as claimed, Appellants submit that independent claims 1, 12, 23 and 34-36 are patentable over the prior art.

Claims 3 and 5 depend from claim 1 and are therefore believed to be patentable for at least the reasons set forth above with respect to claim 1.

Claims 14 and 16 depend from claim 12 and are therefore believed to be patentable for at least the reasons set forth above with respect to claim 12.

Claims 25 and 27 depend from claim 23 and are therefore believed to be patentable for at least the reasons set forth above with respect to claim 23.

B. Claims 2, 13 and 24

Claims 2, 13 and 24 further specify that the light-blocking layer in the liquid crystal light valve as being "formed just below the light shields." Appellants respectfully submit that the cited prior art fails to teach or suggest this arrangement. Instead, Sato clearly discloses that the middle electrode, which the Examiner analogizes to the light shields, and the shading layer, which the Examiner analogizes to the light-blocking layer, are formed in the same layer, namely, second metal layer 160 (Sato; column 14, lines 58-59). Consequently, if two layers are formed in the same layer, one of the layers cannot be formed below the other, as required by the subject claims.

For at least the above reasons, Appellants assert that claims 2, 13 and 24 are separately patentable.

C. Claims 6, 17 and 28

Claims 6, 17 and 28 further specify that the light-blocking layers in the liquid crystal light valve as being "formed by laminating at least one metal selected from the group consisting of Al, Cr-Cr_xO_y, Ti, TiN, and TiN_xC_y." Appellants respectfully submit that Sato fails to teach or remotely suggest that the shading layer 163, which the Examiner analogizes to the light-blocking layer of the claimed invention, is formed as a laminated structure. The Examiner fails to point out with any specificity where in Sato the claimed arrangement is disclosed, and, furthermore, fails to address such additional feature of the claimed invention at all.

For at least the above reasons, Appellants assert that claims 6, 17 and 28 are separately patentable.

Issue 2

Appellants hereby re-allege and incorporate by reference the arguments relating to Issue 1 above in their entirety.

Claims 4, 9-11, 15, 20-22, 26 and 31-33 stand rejected under §103(a) as being unpatentable over Sato, in view of Kahn. Specifically, with regard to claims 4, 15 and 26, the Examiner acknowledges that Sato fails to disclose the materials used to form the insulating layers and/or that the electric circuit formed in the substrate does not include a storage capacitance, as set forth in one or more of the subject claims final Office Action; page 5, last paragraph). However, the Examiner contends that such limitations are disclosed in Kahn. Appellants respectfully disagree with this contention.

Claims 4, 15, and 26 further specify that the electric circuit in the liquid crystal light valve recited in claims 1, 12 and 25, respectively, does not have a storage capacitor. The Examiner contends that Kahn discloses this feature of claims 4, 14 and 26 at column 6, line 67 to column 7, line 2, where it states that "[i]n the second embodiment, the liquid crystal material composition has a large enough intrinsic RC time constant (rho * epsilon greater than one frame) that additional storage capacitors are not needed" (emphasis added). Appellants submit, however, that the Examiner's characterization of the Kahn reference is incorrect.

With reference to FIG. 2 of Kahn, which illustrates a second embodiment of Kahn's invention (Kahn; column 4, lines 32-34), Kahn states that "the second embodiment lacks capacitive layer 66 and insulation layer 68 found in the first embodiment. The lack of these layers provides a less complicated, less costly cell" (Kahn; column 7, lines 9-12). However, while the second embodiment of Kahn may disclose that additional capacitors are not needed (Kahn; column 7, line 2), this embodiment still requires the inclusion of a storage capacitor. Specifically, FIG. 2 of Kahn depicts a storage capacitor comprising a top electrode 70, capacitor structure 64, oxide layers 53 and 50, and bottom electrode 44 (drain bus). This is explicitly described in Kahn at column 5, lines 35-53. Appellants assert that structure 64, which is clearly defined in Kahn as a "capacitor structure" (Kahn; column 5, lines 36-40), is shown in all embodiments described in Kahn (*see, e.g.*, Kahn; FIGS. 1A, 2 and 3). Accordingly, Kahn fails to supplement the deficiencies of Sato.

In view of the foregoing, Appellants respectfully assert that claims 4, 15 and 26 are patentable over the prior art of record, not merely by virtue of their dependency from claims 1, 12 and 25, respectively, which are believed to be patentable for at least the reasons set forth in Issue 1 above, but also in their own right.

Claims 9-11 depend from claim 1 and are therefore believed to be patentable for at least the reasons set forth in Issue 1 above with respect to claim 1.

Claims 20-22 depend from claim 12 and are therefore believed to be patentable for at least the reasons set forth in Issue 1 above with respect to claim 12.

Claims 31-33 depend from claim 23 and are therefore believed to be patentable for at least the reasons set forth in Issue 1 above with respect to claim 23.

Respectfully submitted,

Date: January 14, 2004

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APPENDIX

1. A liquid crystal light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter-substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

2. The liquid crystal light valve according to claim 1, wherein the light-blocking layer is formed just below the light shields.

3. The liquid crystal light valve according to claim 1, wherein the electric circuit in the semiconductor substrate has a storage capacitance.

4. The liquid crystal light valve according to claim 1, wherein the electric circuit in the semiconductor substrate does not have a storage capacitance.

5. The liquid crystal light valve according to claim 1, wherein the stud and the light shields are formed from one substance selected from the group consisting of Ti, W, Mo, Cu, Al, alloys thereof, and compounds thereof with silicon.

6. The liquid crystal light valve according to claim 1, wherein the light-blocking layers are formed by laminating at least one metal selected from a group consisting of Al, Cr-Cr_xO_y, Ti, TiN, and TiN_xC_y.

7. The liquid crystal light valve according to claim l, wherein the third insulating layer has a thickness of 50 Å to 1000 Å.

8. The liquid crystal light valve according to claim 1, wherein the light-reflecting films have ends, and wherein the light shields are formed below the inside peripheral portions of the light-reflecting films at least 0.2 μm from the ends thereof.

9. The liquid crystal light valve according to claim 1, wherein the first, the second, and the third insulating layers contain at least one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, ZrO_x, diamond carbon, and polyamide.

10. The liquid crystal light valve according to claim 9, wherein the first and the second insulating layers are formed from one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, and ZrO_x.

11. The liquid crystal light valve according to claim 9, wherein the third insulating layer is formed from one substance selected from the group consisting of Si_3N_4, TaO_x, and ZrO_x.

12. A liquid crystal light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the inside peripheral portions of the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer are configured to block the incident light from the electric circuit.

13. The liquid crystal light valve according to claim 12, wherein the light-blocking layer is formed just below the light shields.

14. The liquid crystal light valve according to claim 12, wherein the electric circuit in the semiconductor substrate has a storage capacitance.

15. The liquid crystal light valve according to claim 12, wherein the electric circuit in the semiconductor substrate does not have a storage capacitance.

16. The liquid crystal light valve according to claim 12, wherein the stud and the light shields are formed from one substance selected from the group consisting of Ti, W, Mo, Cu, Al, alloys thereof, and compounds thereof with silicon.

17. The liquid crystal light valve according to claim 12, wherein the light-blocking layers are formed by laminating at least one metal selected from a group consisting of Al, Cr-Cr_x0_y, Ti, TiN, and TiN_xC_y.

18. The liquid crystal light valve according to claim 12, wherein the third insulating layer has a thickness of 50 Å to 1000 Å.

19. The liquid crystal light valve according to claim 12, wherein the light-reflecting films have ends, and wherein the light shields are formed below the inside peripheral portions of the light-reflecting films at least 0.2 μm from the ends thereof.

20. The liquid crystal light valve according to claim 12, wherein the first, the second, and the third insulating layers contain at least one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, ZrO_x, diamond carbon, and polyamide.

21. The liquid crystal light valve according to claim 20, wherein the first and the second insulating layers are formed from one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, and ZrO_x.

22. The liquid crystal light valve according to claim 20, wherein the third insulating layer is formed from one substance selected from the group consisting of Si_3N_4, TaO_x, and ZrO_x.

23. A liquid crystal light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap between the light-reflecting films and the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields formed below the area including the inside peripheral portions of the light-reflecting films and the space between the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

24. The liquid crystal light valve according to claim 23, wherein the light-blocking layer is formed just below the light shields.

25. The liquid crystal light valve according to claim 23, wherein the electric circuit in the semiconductor substrate has a storage capacitance.

26. The liquid crystal light valve according to claim 23, wherein the electric circuit in the semiconductor substrate does not have a storage capacitance.

27. The liquid crystal light valve according to claim 23, wherein the stud and the light shields are formed from one substance selected from the group consisting of Ti, W, Mo, Cu, Al, alloys thereof, and compounds thereof with silicon.

28. The liquid crystal light valve according to claim 23, wherein the light-blocking layers are formed by laminating at least one metal selected from a group consisting of Al, Cr-Cr_xO_y, Ti, TiN, and TiN_xC_y.

29. The liquid crystal light valve according to claim 23, wherein the third insulating layer has a thickness of 50 Å to 1000 Å.

30. The liquid crystal light valve according to claim 23, wherein the light-reflecting films have ends, and wherein the light shields are formed below the inside peripheral portions of the light-reflecting films at least 0.2 μm from the ends thereof.

31. The liquid crystal light valve according to claim 23, wherein the first, the second, and the third insulating layers contain at least one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, ZrO_x, diamond carbon, and polyamide.

32. The liquid crystal light valve according to claim 31, wherein the first and the second insulating layers are formed from one substance selected from the group consisting of SiO_2, Si_3N_4, TaO_x, and ZrO_x.

33. The liquid crystal light valve according to claim 31, wherein the third insulating layer is formed from one substance selected from the group consisting of Si_3N_4, TaO_x, and ZrO_x.

34. A projection-type liquid crystal display device comprising:

a light source;

a projection lens; and

a light valve, said light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter-substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

35. A projection-type liquid crystal display device comprising:

a light source;

a projection lens; and

a light valve, said light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap formed between the light-reflecting films and the counter substrate;

counter electrodes provided on the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields provided on the light-blocking layer formed below the inside peripheral portions of the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer are configured to block the incident light from the electric circuit.

36. A projection-type liquid crystal display device comprising:

a light source;

a projection lens; and

a light valve, said light valve comprising:

a plurality of light-reflecting films with one or more spaces therebetween, wherein said light-reflecting films have inside peripheral portions;

a semiconductor substrate connected electrically to the light-reflecting films;

a counter substrate provided on an incident-light side thereof;

liquid crystal disposed in a cell gap between the light-reflecting films and the counter substrate;

an electric circuit formed in the semiconductor substrate, which is configured to apply voltage to the light-reflecting films and the counter electrodes formed on the counter substrate;

a light-blocking layer formed below the light-reflecting films;

a first insulating layer formed between the light-blocking layer and the electric circuit;

a second insulating layer formed between the light-reflecting films and the light-blocking layer;

a stud which is configured to electrically connect the electric circuit and the light-reflecting films;

light shields formed below the area including the inside peripheral portions of the light-reflecting films and the space between the light-reflecting films; and

a third insulating layer formed between the light shields and the light-reflecting films;

wherein at least one of said light shields and said light-blocking layer is configured to block the incident light from the electric circuit.

37. A method for producing a liquid crystal light valve comprising:

(a) forming a semiconductor substrate, wherein said step of forming a semiconductor substrate comprises the sub-steps of:

(i) forming an electric circuit in the semiconductor substrate for a plurality of light-reflecting films;

(ii) forming a first insulating layer on the electric circuit;

(iii) forming a light-blocking layer on the first insulating layer;

(iv) boring a hole for a stud in the light-blocking layer;

(v) forming a second insulating layer on the light-blocking layer, wherein said second insulating layer has an upper surface;

(vi) boring a groove for a stud in the second insulating layer and the first insulating layer;

(vii) boring grooves for light shields in the second insulating layer;

(viii) forming a stud in the hole in the light-blocking layer and in the grooves in the first and the second insulating layers, said stud configured to electrically connect the light-reflecting films and the electric circuit, wherein said stud has an upper surface;

(ix) forming light shields on the light-blocking layer, which shields are configured to block incident light from a space between the light-reflecting films, wherein said light shields have an upper surface;

(x) forming a third insulating layer all over the upper surfaces of the second insulating layer, the stud, and the light shields;

(xi) removing the third insulating layer from the upper surface of the stud; and

(xii) forming the plurality of light-reflecting films patterned for each electric circuit on the third insulating layer; and

(b) forming a liquid crystal panel, wherein said step of forming a liquid crystal panel comprises the sub-steps of:

(i) aligning the semiconductor substrate and a counter substrate having a counter electrode; and

(ii) filling liquid crystal in a cell gap formed by a spacer, said cell gap formed between the light reflecting films and the counter electrodes.

38. The method of claim 37, wherein said sub-steps (a)(vi) and (a)(vii) are performed substantially together, and wherein said sub-steps (a)(viii) and (a)(ix) are performed substantially together.